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Evaluation and Accessing of Data for a Water Resources Simulator

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EVALUATION AND ACCESSING OF DATA FOR A WATER RESOURCES SIMULATOR

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Agricultural Engineering Dept. University of Arkansas

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Research Project Technical Completion Report A-060-ARK

Arkansas Water Resources Research Center
University of Arkansas
Fayetteville, Arkansas 72701



Arkansas Water Resources Research Center

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ABSTRACT

EVALUATION AND ACCESSING OF DATA FOR A WATER RESOURCES SIMULATOR

This report evaluates the availability of data needed to use a groundwater simulation model for real time conjunctive water management in the Arkansas Grand Prairie. It is assumed that the goal of such management is to protect existing groundwater rights by maintaining water levels so that wells do not go dry, even in time of drought.

Sufficient hydrogeologic data exists to use the simulation model to predict the effect of known pumping rates on groundwater levels. Developing an optimal set of "target" levels and annually managing pumping to achieve those levels requires additional data: fall groundwater levels, degree of connection between aquifer and recharge streams, and annual cell by cell prediction of aquaculture and irrigated agriculture acreages. Successful management also requires continuous monitoring in the critical area where saturated thicknesses are small.

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INTRODUCTION AND OBJECTIVES

Arkansas established a Water Code Commission to make recommendations for legislation and rules concerning how Arkansas' water resources should be managed. An option which gained considerable support is the establishment of sub-state water management districts. The Grand Prairie of Arkansas represents a possible prototype water management district. The Arkansas Soil and Water Conservation Commission funded the calibration of a groundwater simulation model for the Quaternary aquifer underlying the Grand Prairie (13). This report supplements that effort by determining data needs appropriate for using the simulator for management.

In this report groundwater management refers to those acts which are necessary: to protect existing water rights by preventing water levels from dropping so much that wells go dry, or to assure the long-term adequacy of the water supply, even in times of drought. The authors assume that the water users themselves should decide if the latter goal is appropriate or desirable. With this in mind, the objectives of this study are to:

- 1) Determine data needs for the effective utilization of a groundwater simulation model for the Grand Prairie Quaternary aquifer.
- 2) Develop appropriate procedures to access available data bases.
- 3) Make recommendations for additional data needs.

The approach is first to report what data is needed for the effective use of the simulation model. Available data and data

bases are subsequently evaluated concerning suitability in meeting data needs. Software and/or procedures to retrieve appropriate data are presented. Finally, recommendations for additional data needs are made.

PROCEDURE

Determination of Data Needs

It is judged desirable to make groundwater management as administratively simple as can be successful. Probably, the period of pumping which a water agency can most readily manage is one year. In other words the agency can, using the simulator, determine how much water can be pumped out of each part of the Prairie in one year's time to meet the area-wide goals of the water users. In practice, the agency will regularly determine whether actual resulting water levels do indeed agree with predictions. Adjustments in permitted pumping may be made as the resources, goals, or needs of the users change.

The user-related data needed for this purpose are estimates of the water requirements in each 3 mile by 3 mile cell of the study area, as affected by climatological conditions. The necessary hydrogeologic information includes:

- effective porosity and hydraulic conductivity of the aquifer (including spatial variations, if significant).
- elevations of the top and bottom of the aquifer material.

- spring and fall elevations of the groundwater level.
- degree of connection between the aquifer and streams which serve as recharge or discharge sites.

At the very least, groundwater levels must be measured annually (in the spring) over the entire area. The USGS has historically made annual measurements in the spring (8,16). Continuity of records must be preserved. It is preferable, however, to make the area-wide measurements on a semi-annual basis (spring and fall). The most important reason for this is that almost all the water is pumped during the summer. Simulation verified every spring and fall could provide more accurate information on the next year's permitted pumping than simulation verified only in the spring. That information would also be available six months earlier. A third reason is that recharge into the study area from its periphery depends largely on the hydraulic gradient from the recharge source towards the area interior. The only estimates of the gradient currently available are those in the spring. At that time the rivers which border and recharge the area are at their highest stage and the aquifer has recovered, as much as it will have opportunity to, from the previous summer's pumping. It is important to know also what the gradient is like in the fall, when recharge streams are at low stage and aquifer water levels have not recovered much from the summer's pumping. Estimates of the degree of connection between the aquifer and penetrating streams are needed to permit approximation of the maximum feasible recharge to or discharge from the aquifer.

Measurements more frequent than semi-annual, over the entire area, would provide little useful information, since the effect of pumping wells during the summer distorts the water levels in their proximity. The process of compensating for that effect to estimate average water levels in the summer would be too time consuming to be justified.

The preceding paragraphs have addressed the necessary data for determining annual permitted pumping volumes. This volume/year flowrate, since it is simple, is necessarily fairly "crude." The temporal distribution of pumping during the summer by independent users can only be estimated. Therefore, resulting summertime saturated thicknesses in some parts of the area could be less than anticipated. For this reason more frequent observations should be made in that part of the study area where saturated thicknesses are critically small. Weekly, daily, or possibly continuous observation and subsequent management action may be necessary to prevent the litigation which can result when wells go dry. Such monitoring also provides a check on the simulation model. This check is needed since no model of an area the size of the Grand Prairie is a perfect predictor.

Evaluation of Available Data Bases and Development of Software for Data Utilization

Predicted water needs for an upcoming year (on a cell by cell basis) are not available in any existing data base. They may,

however, be estimated. The water need for irrigable crops and given climatological conditions (7) can be approximated using a daily simulated water balance. Appendix A contains a procedure which uses the resulting crop water needs, the USGS's 1972 RIDS data base (2,11,12,14) and projected crop acreages to estimate annual water needs for each cell.

The Crop Reporting Service is the most likely source of anticipated acreages (1). An additional source of general information on water use is the excellent periodic water use summary prepared by the USGS (17,18). A more accurate means of estimating the acreages of irrigated crops in each cell is desirable.

Adequate estimates of municipal use of Quaternary groundwater can be made from data in the Arkansas State Water Plan (4). Estimates of aquacultural acreage in each cell can be made from the State Water Plan (3), and records of the Arkansas Fish and Wildlife Service (see Appendix B). It is a common opinion among extension agents that there are thousands of acres of unreported aquaculture. The annual water needs of aquacultural activities range from 3-8 acre-ft/acre. Accordingly, accurate knowledge of aquacultural water needs are important for any management effort.

A simple program was written which sums agricultural, aquacultural and municipal water needs and estimates the pumping from the Quaternary aquifer on a cell by cell basis (Appendix C). Probably, water needs are greater than permissible pumping under

most desirable management strategies. Therefore, an alternative source of water will probably be needed. The physical availability of divertable surface water from the Arkansas or White Rivers can be determined using USGS streamflow records (19).

Several USGS reports (6,10,14) cite estimates of effective porosity or hydraulic conductivity. A review of these is found in a recent report by Peralta, et al. (13). Estimates of the top and bottom of the Quaternary aquifer are found in existing maps (5,9). They may also be created using data from Reports of Water Well Construction (Appendix D) which are filed with the state.¹ These reports contain useful information on the formation, type of water user, well characteristics, etc. The Soil Conservation Service also has a comprehensive listing of wells and surface water diversions. Spring elevations of the piezometric surface are available from USGS reports (8,16). Fall elevations are not available. Standard programs are available on most computer mainframes to grid random three-dimensional observations. Sample procedures include polynomial fitting, spline fitting, and universal kriging. Such programs are used to prepare gridded estimates of the saturated thickness of the aquifer from the data discussed above.

1 It would aid groundwater protection and management in the state if information concerning all strata and their color, and the quarter section in which the well is located were included in all such reports.

Until recently, one well in the Grand Prairie's Quaternary aquifer was continuously monitored. Encrustation of the well ended its usefulness. A new monitoring station has not yet been established (possibly for economic reasons). Continuous monitoring site(s) need to exist in that part of the Prairie where saturated thicknesses are smallest. Preferably, data from the site(s) would be retrieved weekly or as collected (by telemetry). Determination of the number of continuous monitoring sites requires prediction of the effect of future pumping strategies and is beyond the scope of this report.

Estimates of the degree of connection between aquifer and penetrating stream are not available.

CONCLUSIONS AND RECOMMENDATIONS

A program has been written which estimates cell by cell water needs based on available data bases. However, no data base accurately reflects the acreage of irrigated cropland or aquaculture which will probably exist in each cell in the next year. This is an important need. The availability of such information would enable the water management agency better to fill water needs with available groundwater and diverted surface water resources.

Sufficient data is available to estimate the effect of different pumping strategies on future Quaternary groundwater availability in the Grand Prairie. Thus regional pumping strategies can

be developed using a calibrated simulation model (13) and existing data bases. Optimizing or successfully using such strategies will require some additional information.

For most of the Grand Prairie, only spring water levels are currently being measured. This means that a management agency can determine the effect of its management strategy only after every spring. This provides inadequate lead time for determining the subsequent summer's groundwater withdrawal strategy. Thus it is recommended that observations be made in the fall as well as in the spring for all sites currently being annually monitored. It is also suggested that continuous monitoring be used in areas where saturated thicknesses are critically small. The resulting data should be retrieved and analyzed regularly to protect against unexpected dewatering.

The degree of connection between penetrating streams and the aquifer is currently unknown. This should be determined to permit estimation of maximum feasible recharge and the effect of groundwater pumping on the downstream availability of surface water.

BIBLIOGRAPHY

- 1) Agricultural Statistics for Arkansas, 1972-1981. Little Rock, Arkansas. Report Series 262. Crop Report Service, Economics, Statistics, and Cooperatives Service, USDA in Cooperation with the University of Arkansas Agricultural Experiment Station, 1981.
- 2) Arkansas County Profile. Little Rock, AR: Arkansas Department of Local Services, 1977.
- 3) Arkansas State Water Plan, Appendix A, Existing Water and Related Land Resource Development, Little Rock, Arkansas. Arkansas Soil and Water Conservation Commission.
- 4) Arkansas State Water Plan, Appendix B, Public Water Supply Inventory, Little Rock, AR. Arkansas Soil and Water Conservation Commission. 1978.
- 5) "Bottom of Pleistocene, Grand Prairie Rice Region." Confidential Map, Federal Land Bank of St. Louis, MO, 1936.
- 6) Alluvial Aquifer of the Cache and St. Francis River Basins, Northeastern Arkansas. Open-File Report 81-476, USGS, 1981.
- 7) Climatological Data for Arkansas, 1972-1981. Asheville, NC: National Oceanic and Atmospheric Administration. Environmental Data Service, National Climatic Center. 1972-1981.
- 8) Edds, J. Groundwater Levels in Arkansas, Spring 1981. Little Rock, AR. U.S. Geological Survey Open-File Report 81-1114. Arkansas Geologic Commission. 1981.
- 9) "Elevations of Top of Water Bearing Sand (Shallow Wells)", Unpublished Map, Agricultural Engineering Department, University of Arkansas, Fayetteville.
- 10) Engler, K., D. Thompson, R. Kazmann. Groundwater Supplies for Rice Irrigation in the Grand Prairie Region, Arkansas. Fayetteville, AR. Bulletin No. 457, University of Arkansas Agricultural Experiment Station. 1945.
- 11) Monroe County Profile. Little Rock, AR: Arkansas Department of Local Services. 1977.
- 12) Lonoke County Profile. Little Rock, AR: Arkansas Department of Local Services. 1977.

BIBLIOGRAPHY (con't)

- 13) Peralta, R. C., R. Arce and T. Skergan. Grand Prairie Water Supply Project, Phase I, Project Completion Report, October, 1982.
- 14) Prairie County Profile. Little Rock, AR: Arkansas Department of Local Services. 1977.
- 15) Sniegocki, R. T. Hydrogeology of a Part of the Grand Prairie Region. Geological Survey Water Supply Paper 1615-B, 1964.
- 16) Water Levels in Wells that Tap Deposits of Quaternary Age--Shallow Wells. Little Rock, AR. Soil and Water Conservation Commission. 1972-1981.
- 17) Halberg, H. N. Water Use in Arkansas, 1975. Arkansas Geological Commission, Water Resources Summary Number 9. Little Rock, AR. 1977.
- 18) Holland, T. W., and G. Ludwig. Use of Water in Arkansas, 1980. Arkansas Geological Commission, Water Resources Summary Number 14. Little Rock, AR. 1981.
- 19) Water Resources Data for Arkansas Water Year 1977 (and other years). USGS Water-Data Report AR-77-1. Little Rock, AR.

APPENDICES

APPENDIX A

Procedure to Estimate 1983 Agricultural Pumping in Cell M, County A

- ACRE (M) = the agricultural acreage in cell M in 1972 (ac)
- TAGAC (A) = the total agricultural acreage in county A within the study area in 1972 (ac)
- RAGA (A,83) = the expected rice acreage in county A within the study area in 1983 (ac)
- SAGA (A,83) = the expected soybean acreage in county A within the study area in 1983, (irrigated) (ac)
- RIR (83) = irrigation water used for rice irrigation in average years *
- SIR (83) = irrigation water used for soybean irrigation in average years *
- QUAT (A) = the percent of the county's irrigation water which is drawn from the Quaternary aquifer
- Z (A,83) = RAGA (A,83) x RIR (83) + SAGA (A,83) x SIR (83)
- = total expected water need for rice and soybean irrigation in county A in 1983 (ac-ft)
- AGPUMP (M,83) = $Z (A,83) \times \frac{ACRE (M)}{TAGAC (A)} \times QUAT (A)$
- = the volume of water need expected for rice and soybean irrigation in cell M in 1983 (ac-ft) which is pumped from the Quaternary aquifer

* The irrigation water used for rice and soybean irrigation was computed by daily water balance simulation.

APPENDIX B

* PLEASE ESTIMATE PRODUCTION ACRES SO THAT WE CAN ASSIST YOU IN
PLANNING BY ESTABLISHING CHANGING TRENDS IN FISH FARMING.

SPECIES OF FISH	ACRES - 1978	ACRES PLANNED - 1979
Golden Shinner	___ <u>25</u> ___	___ <u>40</u> ___
Fathead Minnows	___ <u>20</u> ___	___ <u>20</u> ___
Catfish (Food) (Brood)	___ <u>25</u> ___	___ <u>25</u> ___
Catfish (Fingerling)	___ <u>315</u> ___	___ <u>315</u> ___
Goldfish	___ <u>15</u> ___	___ <u>25</u> ___
Trout	___ ___	___ ___
Other (Specify) White Am	<u>40</u> ___	<u>40</u> ___
*Total Acres	___ <u>400</u> ___	___ <u>400</u> ___

Lonoke

ENCLOSED IS CHECK OF \$25.00 FOR 1979 RENEWAL OF

FISH FARMER CERTIFICATE NUMBER 220

\$25.00

BULLFROG PERMIT NUMBER

\$25.00 DEC 5 -8

SIGNATURE OF OWNER OR AGENT

ADDRESS IF CHANGED

(PLEASE PRINT)

٧٧٧

CALCULATES THE AMOUNT OF PUMPING FROM THE QUATERNARY AQUIFER IN THE GRAND PRAIRIE REGION, ONLY CONSIDERING RICE AND SOYBEAN ACREAGE (REPORTED FOR EACH COUNTY).

THE FILE TO EXECUTE THIS PROGRAM IS UNDER THE NAME OF
--AUSIMPUM EXEC A--

```
DATA QN/2400*0./
DATA FEMP/468*0./
DIMENSION TP(10,4)
DIMENSION P(10,26,18), P2(10,26,18), P3(10,26,18)
DIMENSION P4(10,26,18)
DIMENSION QNEW(10,30,8)
DATA TAGAC/4*0./, SHVE/4*0./
DATA RAGA/4*0./, SAGA/4*0./, RIP/10*0./, SIR/10*0./
DATA PAX/4*0./, RHY/4*0./, CAXRY/4*0./, SUM/4*0./
DATA PS/4*0./, P6/4*0./, TAQ/4*0./, TAQI/4*0./, TAQII/4*0./
DATA ACPE/468*0./, RMWA/468*0./, TP/4*0./
DATA PAQUA/468*0./
DATA SUMI/10*0./
DATA P/4*0*0*0./, QNEW/2400*0./, P2/4680*0./
DATA P3/4680*0./, P4/4680*0./
DATA ICOUN/468*0*0*0./
DATA ADAQUA/4680*0./
```

AD	00010
AD	00020
AD	00030
AD	00040
AD	00050
AD	00060
AD	00070
AD	00080
AD	00090
AD	00100
AD	00110
AD	00120
AD	00130
AD	00140
AD	00150
AD	00160
AD	00170
AD	00180
AD	00190
AD	00200
AD	00210
AD	00220
AD	00230
AD	00240
AD	00250
AD	00260
AD	00270
AD	00280
AD	00290
AD	00300
AD	00310
AD	00320
AD	00330
AD	00340
AD	00350
AD	00360
AD	00370
AD	00380
AD	00390
AD	00400
AD	00410
AD	00420
AD	00430
AD	00440
AD	00450
AD	00460
AD	00470
AD	00480

```

C      DATA EMPHEC/46P*0./
C      *****
C      READ STATEMENTS
C
C      BOUNDARIES -- FOR ENTIRE MODEL --
C      DO 100 I=1,21
C      READ(5,*)JLEFT(I),JRIGHT(I)
C 100 CONTINUE
C      BOUNDARIES FOR SUBSET MODEL
C      *****
C      FIRST PERFORM A NULL READ ON ADSIMPUM DATA
C
C      DO 110 I=1,22
C      READ(5,*)NLL(I),NRR(I)
C 110 CONTINUE
C
C      NOW READ THE LIMITS OF THE SUBSET OF THE GRAND PRAIRIE
C      FOR THE CALIBRATION RUN TO BE PERFORMED BY AQUISIM
C
C      DO 112 I=1,22
C      READ(9,*)NJLEFT(I),NJRIGHT(I)
C 112 CONTINUE
C      *****
C      READ IN THE TOTAL AG. ACREAGE FOR EACH COUNTY (AC.)
C
C      READ(5,*) (TAGAC(L),L=1,4)
C 150 CONTINUE
C
C      READ IN THE ACREAGE OF IRRIGATED RICE (AC.)
C
C      DO 160 N=1,10
C      READ(5,*) (RAGA(N,L),L=1,4)
C 160 CONTINUE
C
C      READ IN ACREAGE OF IRRIGATED SOYBEAN (AC.)
C
C      DO 170 N=1,10
C      READ(5,*) (SAGA(N,L),L=1,4)
C 170 CONTINUE
C

```

```

AD 00490
AD 00500
AD 00510
AD 00520
AD 00530
AD 00540
AD 00550
AD 00560
AD 00570
AD 00580
AD 00590
AD 00600
AD 00610
AD 00620
AD 00630
AD 00640
AD 00650
AD 00660
AD 00670
AD 00680
AD 00690
AD 00700
AD 00710
AD 00720
AD 00730
AD 00740
AD 00750
AD 00760
AD 00770
AD 00780
AD 00790
AD 00800
AD 00810
AD 00820
AD 00830
AD 00840
AD 00850
AD 00860
AD 00870
AD 00880
AD 00890
AD 00900
AD 00910
AD 00920
AD 00930
AD 00940
AD 00950
AD 00960

```

APPENDIX C
(Continued)

C		AD 00970
C	READ IN THE IRRIGATION REQUIREMENTS FOR RICE FOR EACH YEAR (IN.)	AD 00980
C	DO 180 N=1,10	AD 00990
	READ(5,*)RIR(N)	AD 01000
180	CONTINUE	AD 01010
C		AD 01020
C	READ IN THE IRRIGATION REQUIREMENTS FOR SOYBEANS PER YEAR (IN.)	AD 01030
C	DO 190 N=1,10	AD 01040
	READ(5,*)SIR(N)	AD 01050
190	CONTINUE	AD 01060
C		AD 01070
C	READ IN THE COUNTY THAT EACH CELL IS IN	AD 01080
C	DO 200 I=1,17	AD 01090
	IL=JLEFT(I)+1	AD 01100
	IR=JRIGHT(I)+1	AD 01110
	READ(5,*)(ICOUN(I,J),J=IL,IR)	AD 01120
200	CONTINUE	AD 01130
C		AD 01140
C	*****	AD 01150
C	DO 210 I=1,17	AD 01160
	WRITE(6,*) (ICOUN(I,J),J=1,17)	AD 01170
210	CONTINUE	AD 01180
C	*****	AD 01190
C	READ IN THE AGRICULTURAL AREA IN EACH CELL (SQUARE KM.)	AD 01200
C	DO 300 I=1,17	AD 01210
	IL=JLEFT(I)+1	AD 01220
	IR=JRIGHT(I)+1	AD 01230
	READ(5,*)(ACRE(I,J),J=IL,IR)	AD 01240
300	CONTINUE	AD 01250
C		AD 01260
C	READ IN THE PERCENTAGE OF AGRICULTURAL WATER COMING FROM	AD 01270
C	PUMPING UP THE QUATERNARY AQUIFER	AD 01280
C	READ(5,*)(SHWE(L),L=1,4)	AD 01290
C		AD 01300
C	READ IN THE MUNICIPAL WATER USE BY LOCATION (AC.-FT.)	AD 01310
C		AD 01320
C		AD 01330
C		AD 01340
C		AD 01350
C		AD 01360
C		AD 01370
C		AD 01380
C		AD 01390
C		AD 01400
C		AD 01410
C		AD 01420
C		AD 01430
C		AD 01440

APPENDIX C
(Continued)

```

C      THE CELL NUMBERS FOR READING IN THE MUNICIPAL WATER USE
C      ARE THE I AND J VALUES
C
C      DO 350 NUM1=1,9
C      READ(5,*) I,J
C      READ(5,*) MMWA(I,J)
350    CONTINUE
C
C      READ IN THE VALUE FOR THE TOTAL AQUACULTURAL WATER REQUIREMENT
C      (BY CELL NUMBER AS ABOVE) THIS NUMBER WILL BE MULTIPLIED
C      BY 0.9 BECAUSE 90% OF THE WATER COMES FROM THE
C      QUATERNARY AQUIFER. ....(AC.-FT.)
C      DO 360 NUM=1,24
C      READ(5,*) I,J
C      READ(5,*) RAQUA(I,J)
C      RAQUA(I,J)=0.9*RAQUA(I,J)+1.00
360    CONTINUE
C
C      *****
C      ADDITIONAL INPUT (RECHARGE & AQUACULTURE)
C
C      ADAQUA(K,I,J)  ADDITIONAL AQUACULTURAL PUMPING (AC.-FT.)
C                      K IS THE YEAR
C
C      EMPREC(I,J)    EMPJIRICAL RECHARGE CONSTANT
C                      (CUBIC FT.)/YEAR X (10 TO THE 7TH.)
C
C      DO 365 NUM2=1,13
C      READ(5,*) I,J,FEMP(I,J)
C      EMPREC(I,J)=FEMP(I,J)*(10**7)
365    CONTINUE
C
C      DO 367 NUM3=1,17
C      READ(5,*) I,J,ADAQUA(6,I,J)
C      ADAQUA(6,I,J)=ADAQUA(6,I,J)+1.00
C      DO 366 NY=7,10
C      ADAQUA(NY,I,J)=ADAQUA(6,I,J)
C      CONTINUE
366    CONTINUE
367    CONTINUE
C
C
C

```

```

AD 01450
AD 01460
AD 01470
AD 01480
AD 01490
AD 01500
AD 01510
AD 01520
AD 01530
AD 01540
AD 01550
AD 01560
AD 01570
AD 01580
AD 01590
AD 01600
AD 01610
AD 01620
AD 01630
AD 01640
AD 01650
AD 01660
AD 01670
AD 01680
AD 01690
AD 01700
AD 01710
AD 01720
AD 01730
AD 01740
AD 01750
AD 01760
AD 01770
AD 01780
AD 01790
AD 01800
AD 01810
AD 01820
AD 01830
AD 01840
AD 01850
AD 01860
AD 01870
AD 01880
AD 01890
AD 01900
AD 01910
AD 01920

```

APPENDIX C
(Continued)

```

C      *****
C      COMPUTATIONS
C      DO 400 N=1,10
C      DO 375 L=1,4
C      RAX(N,L)=RAGA(N,L)*RIP(N)
C      RAY(N,L)=SAGA(N,L)*SIP(N)*0.2915
C      THE FACTOR 0.2915 WAS ADDED TO REDUCE THE ASSUMED
C      SOYBEAN ACREAGE IRRIGATED.
C      CAXBY(N,L)=((RAX(N,L)+RAY(N,L))/TAGAC(L))/12.0)*1.00
C      THE FACTOR '1.00' IN THE ABOVE LINE IS FOR THE CONVEYANCE LOSS
375  CONTINUE
400  CONTINUE
      DO 500 N=1,10
      DO 490 I=2,21
      IL=NJLFFI(I)+1
      IF(I.EQ.8)IL=NJLEFT(I)+2
      IP=NJRII(I)-1
      DO 480 J=IL,IP
      L=LCOUN(I,J)
      P(N,I,J)=((ACRE(I,J)*(247.11)*CAXBY(N,L)*SHWE(L)+RMWA(I,J)
      *RAQUA(I,J)-(0.03*640.*9.)+(ADAQUA(N,I,J)))*43560.)
      DO XEDIT: CA -(EMPRFC(I,J))
      TO THE ABOVE COMPUTATION IF EMPIRICAL RECHARGE IS WANTED.
C      P3(N,I,J) IS THE PUMPING IN ***** ACRE FEET *****
C      P3(N,I,J)=P(N,I,J)/43560.
C      P4(N,I,J) IS THE PUMPING IN ***** FEET PER CELL *****
C      P4(N,I,J)=P3(N,I,J)/640./9.
C      P2(N,I,J) IS THE AGRICULTURAL PUMPING IN ***** ACRE FEET *****
C      P2(N,I,J)=(ACRE(I,J)*247.11*CAXBY(N,L)*SHWE(L))
C      RICE TOTAL IS P5
C      P5(N,L)=(ACRE(I,J)*247.11*RAX(N,L)/TAGAC(L)/12.0)*SHWE(L)+P5(N,L)
C      SOYBEAN TOTAL IS P6
C      P6(N,L)=(ACRE(I,J)*247.11*RAY(N,L)*SHWE(L)/TAGAC(L)/12.0)+P6(N,L)
C      AQUACULTURAL PUMPING (INITIAL INPUT) IS TAQI(N,L)
C      TAQI(N,L)=RAQUA(I,J)+TAQI(N,L)
C      AQUACULTURAL PUMPING (ADDITIONAL INPUT) IS TAQII(N,L)
C      TAQII(N,L)=ADAQUA(N,I,J)+TAQII(N,L)

```

```

AD 01930
AD 01940
AD 01950
AD 01960
AD 01970
AD 01980
AD 01990
AD 02000
AD 02010
AD 02020
AD 02030
AD 02040
AD 02050
AD 02060
AD 02070
AD 02080
AD 02090
AD 02100
AD 02110
AD 02120
AD 02130
AD 02140
AD 02150
AD 02160
AD 02170
AD 02180
AD 02190
AD 02200
AD 02210
AD 02220
AD 02230
AD 02240
AD 02250
AD 02260
AD 02270
AD 02280
AD 02290
AD 02300
AD 02310
AD 02320
AD 02330
AD 02340
AD 02350
AD 02360
AD 02370
AD 02380
AD 02390
AD 02400

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APPENDIX C
(Continued)

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C      TOTAL AQUACULTURAL PUMPING IS TAO(N,L)
      TAO(N,L)=MAQUA(I,J)+ADAQUA(N,I,J)+TAQ(N,L)
C
C      TP(N,L) IS THE PUMPING FOR THE COUNTY
C
      TP(N,L)=P(N,I,J)
C
C      SUM(N,L) IS THE TOTAL PUMPING FOR EACH COUNTY
      SUM(N,L)=SUM(N,L)+TP(N,L)
490    CONTINUE
C
C      SUMT(N) IS THE TOTAL PUMPING FOR THE YEAR (ACRE FEET)
      SUMT(N)=SUMT(N)+SUM(N,L)
490    CONTINUE
C      THE NEXT THREE STATEMENTS ADDED 3/3/P3.
C      THEY ADD RECHARGE TO THE THREE CELLS INCLUDED.
C      THE RECHARGE IS THE AVERAGE OF THE STEADY STATE PUMPING VALUES
      FROM THE OUTPUT OF 11/15/82.
      P(N,18,11)=P(N,18,11)-6135000.
      P(N,19,12)=P(N,19,12)-16103000.
      P(N,21,13)=P(N,21,13)-202140000.
500    CONTINUE
C
C      *****
C
C      THIS NEXT PART WAS ADDED TO WRITE OUT THE PUMPING IN A
      FORMAT WHICH SIMULAT MUST READ IT
C
      DO 590 N=1,10
        ICO=1
        DO 570 I=1,22
          LL=NJLFFI(I)
          LR=NJRIIT(I)
          DO 550 J=LL,LR
            QN(N,ICO)=P(N,I,J)
            WRITE(6,907) (ICO,QN(N,ICO))
            ICO=ICO+1
550        CONTINUE
570      CONTINUE
590    CONTINUE
      DO 595 N=1,10
        ICO=0
        DO 594 I=1,26
          DO 592 J=1,8
            ICO=ICO+1
            QNEW(N,I,J)=QN(N,ICO)
            WRITE(6,908) (ICO,QNEW(N,I,J),QN(N,ICO))
592        CONTINUE

```

```

AD 02410
AD 02420
AD 02430
AD 02440
AD 02450
AD 02460
AD 02470
AD 02480
AD 02490
AD 02500
AD 02510
AD 02520
AD 02530
AD 02540
AD 02550
AD 02560
AD 02570
AD 02580
AD 02590
AD 02600
AD 02610
AD 02620
AD 02630
AD 02640
AD 02650
AD 02660
AD 02670
AD 02680
AD 02690
AD 02700
AD 02710
AD 02720
AD 02730
AD 02740
AD 02750
AD 02760
AD 02770
AD 02780
AD 02790
AD 02800
AD 02810
AD 02820
AD 02830
AD 02840
AD 02850
AD 02860
AD 02870
AD 02880

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APPENDIX C
(Continued)


```

594      CONTINUE
595      CONTINUE
      DO 598 N=1,10
      DO 597 I=1,26
      WRITE (7,204) (ONFW(N,I,J),J=1,8)
597      CONTINUE
598      CONTINUE
C
C
C
C
C
C
      *****
      *****
      WRITING OUT THE SUM OF THE PUMPING FOR EACH COUNTY BY YEAR
      FOR THE TOTAL PUMPING, THE PUMPING FOR RICE IRRIGATION,
      AND THE PUMPING FOR SOYBEAN IRRIGATION
      DO 620 K2=1,6
      IYEAR=1971
      IF (K2.EQ.6) GO TO 608
      IF (K2.EQ.5) GO TO 606
      IF (K2.EQ.4) GO TO 604
      IF (K2.EQ.3) GO TO 602
      IF (K2.EQ.2) GO TO 600
      WRITE (6,920)
      GO TO 612
600  WRITE (6,911)
      GO TO 612
602  WRITE (6,912)
      GO TO 612
604  WRITE (6,914)
      GO TO 612
606  WRITE (6,916)
      GO TO 612
608  WRITE (6,918)
612  WRITE (6,925)
      WRITE (6,930)
      DO 618 N=1,10
      IYEAR=IYEAR+1
      IF (K2.EQ.6) GO TO 617
      IF (K2.EQ.5) GO TO 616
      IF (K2.EQ.4) GO TO 615
      IF (K2.EQ.3) GO TO 614
      IF (K2.EQ.2) GO TO 613
      WRITE (6,900) (IYEAR, (SUM(N,L),L=1,4),SUMT(N))
      GO TO 618
613  WRITE (6,900) (IYEAR, (PS(N,L),L=1,4))
      GO TO 618
614  WRITE (6,900) (IYEAR, (P6(N,L),L=1,4))
      GO TO 618
AD 02890
AD 02900
AD 02910
AD 02920
AD 02930
AD 02940
AD 02950
AD 02960
AD 02970
AD 02980
AD 02990
AD 03000
AD 03010
AD 03020
AD 03030
AD 03040
AD 03050
AD 03060
AD 03070
AD 03080
AD 03090
AD 03100
AD 03110
AD 03120
AD 03130
AD 03140
AD 03150
AD 03160
AD 03170
AD 03180
AD 03190
AD 03200
AD 03210
AD 03220
AD 03230
AD 03240
AD 03250
AD 03260
AD 03270
AD 03280
AD 03290
AD 03300
AD 03310
AD 03320
AD 03330
AD 03340
AD 03350
AD 03360

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APPENDIX C
(Continued)

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615 WRITE(6,900) (IYEAR, (TAQI(N,L).L=1,4))
GO TO 618
616 WRITE(6,900) (IYEAR, (TAQII(N,L).L=1,4))
GO TO 618
617 WRITE(6,900) (IYEAR, (TAQ(N,L).L=1,4))
618 CONTINUE
620 CONTINUE

*****

THE NEXT STATEMENTS ARE ONLY TO CREATE THE SAME
DATA INTO A FILE THAT CAN BE USED BY SAS.

DO 700 N=1,10
  DO 690 L=1,4
    WRITE(6,940) N,L,SUM(N,L)
  CONTINUE
690 CONTINUE
700 CONTINUE

*****

THIS PART ADDED 8/25/82 TO WRITE THE WATER USE IN MAP FORM

A: AGRICULTURAL LAND, IN ACRES
DO 720 I=1,22
  DO 720 J=1,18
    ACRE(I,J)=ACRE(I,J)*247.11
  CONTINUE
  WRITE(6,741)
721 FORMAT(/,'1',20X,'AGRICULTURAL LAND USE CELL BY CELL, AC.',/)
  DO 722 I=1,22
    WRITE(6,744) (ACRE(I,J),J=1,18)
  CONTINUE
722 CONTINUE
724 FORMAT(2X,18F7.0,/)

A2: PUMPING DUE TO AGRICULTURE, ACRE-FT
727 FORMAT('1',20X,'PUMPING DUE TO AGRICULTURE, ACRE-FT',3X,15,/)
DO 728 N=1,10
  IYEAR=1971+N
  WRITE(6,741) IYEAR
791 FORMAT(//////////,20X,'YEAR = ',I4,/)

```

	DO 728 I=1,22	AD 03850
	WRITE(6,729) (PMW(N,I,J),J=1,18)	AD 03860
	728 CONTINUE	AD 03870
	729 FORMAT(2X,18F7.0,/))	AD 03880
C		AD 03890
C		AD 03900
C		AD 03910
C	B: MUNICIPAL WATER USE, ACRE-FT	AD 03920
C		AD 03930
	WRITE(6,731)	AD 03940
731	FORMAT(11,20X,'MUNICIPAL WATER USE, ACRE-FT',//)	AD 03950
	DO 732 I=1,22	AD 03960
	WRITE(6,734) (PMWA(I,J),J=1,18)	AD 03970
732	CONTINUE	AD 03980
734	FORMAT(2X,18F7.0,/))	AD 03990
C		AD 04000
C		AD 04010
C		AD 04020
C		AD 04030
C		AD 04040
C	C: AQUACULTURAL WATER USE, ACRE-FT	AD 04050
C		AD 04060
	WRITE(6,741)	AD 04070
741	FORMAT(11,20X,'AQUACULTURAL PUMPING, ACRE-FT',//)	AD 04080
	DO 740 I=1,22	AD 04090
	WRITE(6,744) (AQW(I,J),J=1,18)	AD 04100
740	CONTINUE	AD 04110
744	FORMAT(2X,18F7.0,/))	AD 04120
C		AD 04130
C		AD 04140
C		AD 04150
C		AD 04160
C	ADDITIONAL INPUT	AD 04170
	WRITE(6,747)	AD 04180
	DO 746 I=1,22	AD 04190
	WRITE(6,746) (ADAQW(I,J),J=1,18)	AD 04200
746	CONTINUE	AD 04210
C		AD 04220
C		AD 04230
	WRITE(6,748)	AD 04240
	DO 749 I=1,22	AD 04250
	WRITE(6,752) (FEMP(I,J),J=1,18)	AD 04260
749	CONTINUE	AD 04270
C		AD 04280
C		AD 04290
	747 FORMAT(11,10X,'ADDITIONAL AQUACULTURAL PUMPING 1977-1981 ACREAD	AD 04300
		AD 04310
		AD 04320

APPENDIX C
(Continued)

Line	Code	Statement	Address
748		FORMAT(11,10X,'EMPIRICAL RECHARGE CONSTANT EVERY YEAR',5X,'INAD	04330
		*(CUMULIC F1.) X (10 TO THE 7TH. ',,/,)	04340
			04350
			04360
			04370
			04380
			04390
			04400
			04410
753		WRITE(6,753)	04420
		FORMAT(11,20X,'TOTAL PUMPING CELL BY CELL',,/,)	04430
		DO 751 N=1,10	04440
		IFAR=1971+N	04450
		WRITE(6,750) IYEAR	04460
		DO 750 I=1,22	04470
		WRITE(6,755) (P3(N,I,J),J=1,18)	04480
750		CONTINUE	04490
751		CONTINUE	04500
755		FORMAT(2X,18F7.0,/,)	04510
756		FORMAT(11,15X,'TOTAL PUMPING CELL BY CELL IN (AC FT)',3X,I6,/,)	04520
			04530
			04540
			04550
			04560
			04570
			04580
			04590
787		FORMAT(11,5X,'TOTAL PUMPING IN FT. PER CELL YEAR = ',I4,/,)	04600
		DO 785 I=1,22	04610
		WRITE(6,886) (P4(N,I,J),J=1,18)	04620
886		FORMAT(2X,18F7.3,/,)	04630
786		FORMAT(2X,18F7.0,/,)	04640
752		FORMAT(2X,18F7.2,/,)	04650
785		CONTINUE	04660
			04670
			04680
			04690
900		FORMAT(4X,I4,2X,4E14,7,2X,E14,7,/,)	04700
904		FORMAT(8E10,4)	04710
907		FORMAT(4X,I4,2F10,2)	04720
908		FORMAT(4X,I5,2F10,2)	04730
902		FORMAT(4X,18F5,0)	04740
		FORMAT(8E10,4)	04750
910		FORMAT(4X,20I3)	04760
911		FORMAT(11,15X,' RICE IRRIGATION PUMPING IN ACRE-FT. ',,/,/,/,)	04770
912		FORMAT(11,15X,' SOYBEAN IRRIGATION PUMPING IN ACRE-FT.',,/,/,/,)	04780
914		FORMAT(11,15X,' INITIAL AQUACULTURAL PUMPING IN ACRE-FT.',,/,/,/,)	04790
916		FORMAT(11,15X,' ADDITIONAL AQUACULTURAL PUMPING IN ACRE-FT.',,/,/,/,)	04800

APPENDIX D

ST-1054

STATE OF ARKANSAS

REPORT OF WATER WELL CONSTRUCTION

*Yes ☒ No ☐ ☐ Work-over Well ☐ Replacement Well
 Owner of Well J. J. Jones
 Well Contractor Layne Arkansas Company SE 1/4
 Contractor License No. C-1099
 Driller Name and No. Harvey Bullock - D-2204
 Date Well was Completed May 9, 1979

County Arkansas
in which well is located

Well is near Road
 Section 5 Township 2S Range 5W
 Directions for Reaching Well: On North side of his farm (use permanent landmarks)
about 3 miles North of town

1. Total Depth of Well 636' Ft.
2. Water Producing Formation: From 556 Ft.
To 636 Ft.
3. Water Level Below Land Surface 134' Ft.
4. Gallons per Hour 78000
5. Well Disinfected with HTH
6. Casing to 542 Ft.
7. Cased with 12" Diameter 250 Casing
8. Cemented from 0 Ft. to 542 Ft.
- X
9. Use of Well: Domestic Irrigation Municipal Other
- This well is guaranteed against defective material or workmanship for a period of 1 Year

Description and Color of Formation (sand, shale, sandstone, etc.)	Depths	in feet
	from	to

"See Attached Sheet"

Remarks: _____
Signed: W. L. K. Smith Date: 5/16/79

Form NC AWD-2

Mail to: Committee on Water Well Construction, 2915 So. Pine Street
Little Rock, Arkansas 72204

Geology Copy

TOTAL DEPTH	THICKNESS EACH STRATUM	FORMATION
35	35	Red Sandy Clay
70	35	Red Clay
100	30	Fine Sand
136	36	Coarse Sand & Gravel
235	99	Gumbo
236	1	Rock
244	8	Gumbo
245	1	Rock
280	35	Gumbo
295	15	Fine Sand & Stks. of Shale
369	74	Gumbo
445	76	Sandy Shale
522	77	Gumbo
547	25	Fine Sand
633	86	Medium Sand
648	15	Gumbo
670	22	Sandy Shale